My research is in the area of **information visualization** and **human-computer interaction** (HCI). More specifically, my focus is on visualization for intelligence amplification: using visual tools for improving the perceptive, cognitive, and analytical capabilities of people to allow them to solve tasks that were previously too large or too complex. Humans have used technology to improve their capabilities and overcome their limitations since the beginning of time. Computers and interactive graphics are just tools in a long line of tools, but their potential for supporting the human in processing information is unparalleled.

My research methodology is a mix of theory, design, and evaluation. The problems I attack are real problems posed by real users, and I strive to involve these users in the design process in a user-centered, participatory fashion. Because the problems are real, all of my work is characterized by a strong technical component. New HCI techniques and tools must be empirically evaluated, and for this to be possible there must be prototype implementations. After an iterative design and development phase, my approach is to evaluate the performance of the new technique or tool using a blend of qualitative and quantitative methods.

One gratifying aspect of visualization is that it is by its very nature cross-disciplinary, since we are almost always visualizing someone else’s data. So far, I have had the opportunity to visualize data from domains ranging from biology and graphic design to architecture and social science. I am currently working with cognitive psychologists on the use of motion for pointing, and I am very interested in collaboration with researchers from other disciplines.

**Past Research**

There is a very clear limit to how many pixels, colors, and individual graphical entities the human perceptual system can handle—after this limit has been exceeded, we must look beyond mere visual representations to be able to manage the massive datasets given to us. Interaction provides a powerful means to achieve this by placing the control of the visual representation in the hands of the users themselves. For example, the Mélange interaction technique [1] brings together multiple focus regions in a large 2D space by folding the intervening space into 3D. This is useful for simultaneously browsing several areas on a large map at high detail while retaining the overall context, studying time-series data spanning long periods of time, or editing a video as a sequence of image frames.

In visual analytics, we must support the whole analysis process, from initial exploration, through gaining insights, and all the way to communicating the results of the analysis to stakeholders. My approach is based on providing smooth and seamless interaction techniques to allow for selecting, filtering, and combining the data, not only within visualizations but between several different ones. In the DataMeadow [2], I extended traditional dynamic query sliders (as utilized in the Spotfire platform, among others) to a hierarchical structure and provided a set of rich interaction techniques to allow for iterative refinement of queries.

For massive datasets, we invariably reach a point when there simply are not enough pixels to go around (large displays can help here, but only to a certain point). In my research, I have also focused on aggregation strategies for handling this very situation, where we recursively combine several data points into a hierarchy of discrete zoom levels to create a multiscale representation of the data. The problem is then twofold: (1) visually representing these aggregate entities that consist of potentially thousands of data cases, and (2) providing the necessary interaction techniques for navigating this multiscale space. In the ZAME graph visualization tool [3], my collaborators and I attacked these problems by employing program-
mable shaders to effectively render visual aggregates in real time, and designed a set of inter-
action techniques tailored at traversing the multiscale environment.

Addressing the perceptual side of the visualization process requires us to study the human
perceptual system and ways to augment it. In my dissertation, I devoted great effort towards
dealing with the occlusion problem in 3D environments, where nearby objects can hide more
distant objects from view. My approach is based on a taxonomy [4] of the design space and
consists of four general strategies. I have developed concrete techniques for each of them:

- The view-projection animation [5] technique that displays two views of a scene using
  perspective and parallel projection, as well as a smooth animated transition between them;
- Image-space dynamic transparency [6] providing a virtual X-Ray vision mechanism that
  allows users to see through distracting objects to discover occluded targets;
- The 3D navigation guidance [7][8] method for presenting occluded targets by taking the
  user on a guided tour through the 3D world; and
- The BalloonProbe [9] that allows for interactive object-space distortion using a 3D force
  field that can be inflated and deflated by the user.

Future Research
My future research will fit within the general goal of augmenting human intelligence through
visual tools, but the actual problems I attack will be open to outside input, trends, and needs.
Below follows a sampling of both short-term and long-term projects that I am currently
involved in or plan to launch (independently or with collaborators):

- Interaction capture, visualization and history: Capturing interaction history in information
  visualization applications to allow for analysis (evaluation and benchmarking), session
  representation (storytelling and session history), and replay (recall and copy-and-paste).
- Annotation for visual analytics: Annotation is a ubiquitous and central component of
  visual exploration. This project surveys methods for annotation to support collecting
  insights, drawing conclusions, and producing reports.
- Interaction techniques for massive data: As has been previously discussed in this docu-
  ment, interaction is a powerful tool for exploring and understanding massive datasets.
  This project deals with new interaction techniques for achieving this.
- Augmentation in games: Many tasks in modern computer games are difficult without
  contributing to gameplay. In this project, I study how to use HCI and visualization to aug-
  ment human capabilities for such tasks without interfering with gameplay aspects.
- Direct manipulation in information visualization: Many information visualization applica-
  tions are controlled through dialogs, but this may be detrimental to productivity. Here, I
  will explore how to introduce more direct manipulation in such applications.

Outlook
My goal is for my work to both have short-term as well as long-term impact. In the short
term, I plan on taking an active role in the research community for information visualization
and visual analytics, and promoting an agenda of visualization for intelligence amplification
in these communities. In the longer term, I will work towards disseminating my research to
industry and society, as well as integrating my new techniques and tools in real interactive
systems. The ultimate goal is to enable real users to solve real tasks—such as understanding
massive-scale multidimensional data, seeing the structure of huge hierarchies, or navigating
large information spaces—that they were previously not able to solve. Another important goal is to contribute to improving the theoretical foundations of HCI and visualization, beyond today’s prevalent empiricism.

Funding is an important aspect for any active researcher. I have so far been quite successful at this as a student, experience that will serve me well when adapting to the role of a full-time faculty member. In 1999, while still an advanced undergraduate, I was able to attract a large (US $17,000) equipment grant from Xybernaut Corporation for my work on the 3Dwm platform for 3D interaction research. As a Ph.D. student, I was also funded (US $7,500) in 2005 for visiting Georgia Institute of Technology during spring 2006. I anticipate seeking future funding from both private and public sources. In particular, visualization, HCI, and visual analytics research has recently received much interest from both government agencies (such as NSF, DHS, and DOE in the US, NSERC in Canada, and the EU Research Framework Programme in Europe), as well as companies (such as my postdoctoral fellowship funded by Microsoft Research).

In closing, the reason I choose to pursue an academic career is that I am not only passionate about information visualization and HCI research, but that I would also like to participate in training the next generation of HCI researchers and practitioners. Working as a university professor would allow me to convey this passion to my students, undergraduates and graduates alike, and to involve them in meaningful research projects that might spark the same interest that my teachers once gave me.

**Selected Publications**


